# Development of an integrated readout electronics system for a highly granular scintillator-tungsten calorimeter prototype for the CEPC

A. Zhou[1,2], Z. Shen[*,1,2], H. Liu[1,2], J. Liu[1,2], S. Liu[1,2]

**1 State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China**

**2 Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China**

***Corresponding author**

## Introduction

Higgs boson is of great significance to the development of high energy physics.

CEPC(Circular Electron-Positron Collider) is the first phase of CEPC-SPPC. CEPC could generate positive and negative electron pairs with a centroid energy of up to 240 GeV, which collide in the ring at a time interval of about 3.5 us, with a brightness of $2*10^{34}cm^{-2}s^{-1}$, and generate a large number of Higgs particles and Z particles.

ECAL (Electromagnetic Calorimeter) s an important part of CEPC concept detector. The electromagnetic energy meter mainly measures 30% of photons in jet. To achieve this goal, the pre research technical scheme adopts the way of scintillator array + SiPM stack, and forms a sampling type energy meter with tungsten plate absorber.

## Aim

The research purpose of this subject is to study the readout electronics for the technical route of imaging calorimeter scintillator + SiPM. The design and implementation of the electronics system for detector mainly focus on the following points:

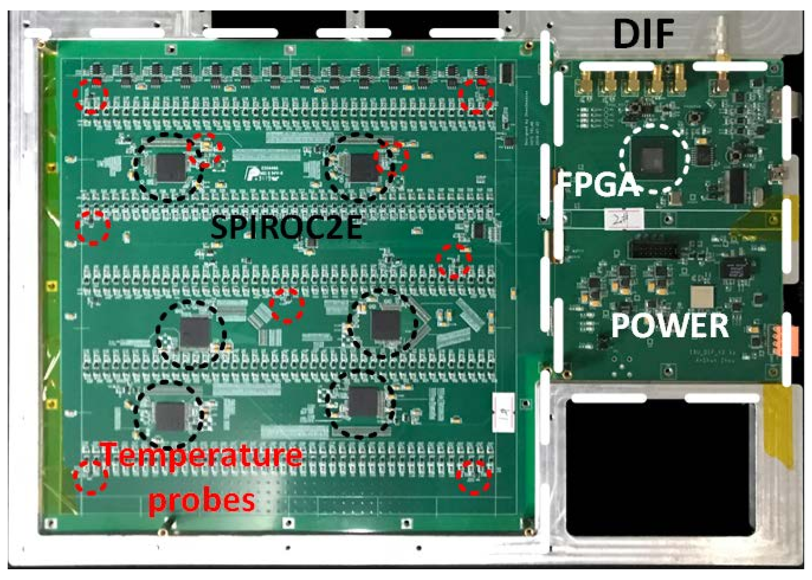
- SiPM-oriented front-end electronics with low power consumption and high integration
- Large-scale data acquisition system with high data bandwidth and strong compatibility
- 2 calibration systems which could monitor the working condition of the prototype online

## Development of the electronics system

➢ **Research on highly integrated, low-power consumption front-end**

- Using Spiroc2E as read-out chip

Spiroc2E is integrated with 36 read-out channels and the power consumption of every channel is as low as 8mW. Every electronics layer contains 6 Spiroc2E which is in charge of the read-out of 210 channels of detectors.




*As shown in Fig 1, there are 6 Spiroc2E located on every layer. To monitor the temperature of the ECAL temperature probes were also set on the PCB.*

*On the right side lies the data interface board(DIF). The data generated by Spiroc2E would be acquired by the DIF board.*

*Fig. 1 ECAL prototype Basic Unit(EBU)*

- High-density assembly of scintillators and SiPM

To improve the integration of the read-out electronics system, a special design of the PCB was come up with. In order to allow a single PCB to be integrated with SiPM and Scintillator, all the electronic devices are set on the same side of the PCB. SiPM and scintillator was coupled on the other side of the PCB.

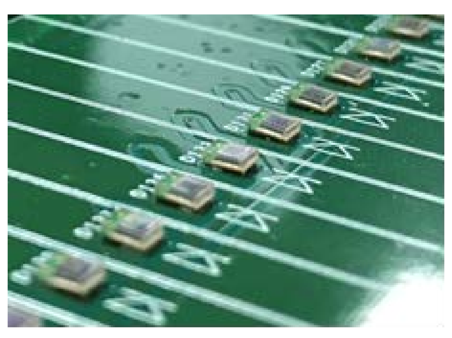


*Fig. 2 SiPM location*

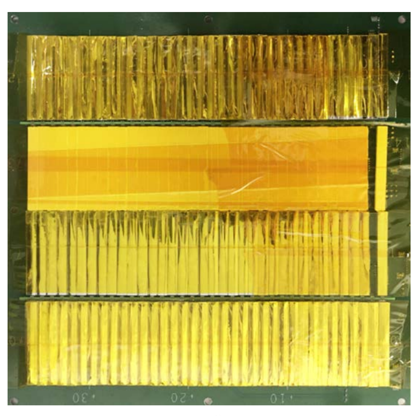


*Fig. 3 Picture of the Scintillator assembled on PCB*

➢ **Design of Large-scale data acquisition system for ECAL**

- Structure of read-out system

GigaBit Transceiver was designed to handle the acquisition of all the data generated by the EBU as well as the control of the working state of every layer.

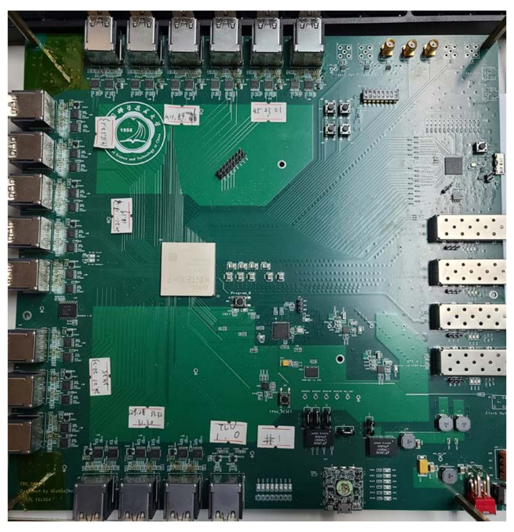


*Fig. 4 Picture of the GBT board*

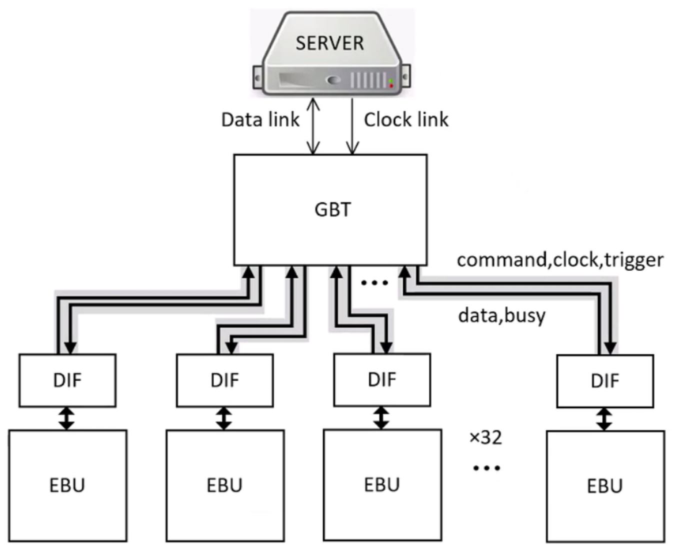



*Fig. 5 Readout structure of the prototype*

As shown in Fig.5 data from the EBU would be acquired by the GBT board and saved in the server at last. The command from the server would be distributed to the EBU through the GBT board. The data rate of the system could up to 4.8 Gbps. This system could keep in a stable working state in the long-term test.

➢ **Calibration systems**

In order to monitor the working condition of prototype, 2 calibration system was integrated in the readout system.

- Electrical calibration system

The principle of the electrical calibration is to inject charge to Spiroc2E manually. The basic circuit of electrical calibration system is shown in fig.6. Adjust the output of DAC could get different amount of charge injected.

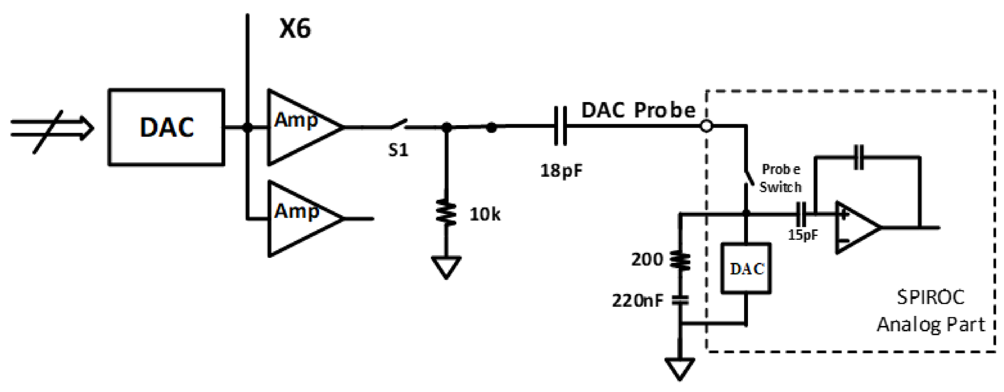



*Fig. 6 Circuit of electrical calibration system*

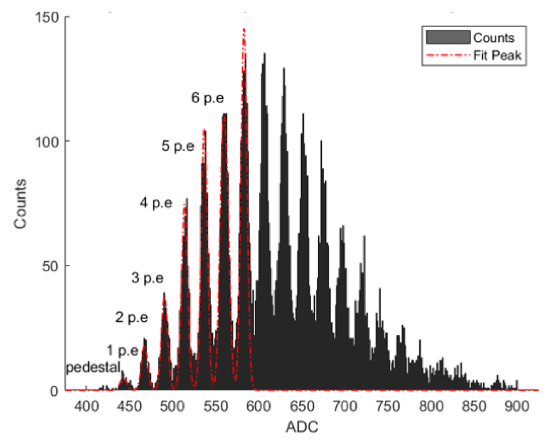


*Fig. 7 single photoelectron spectrum*

- Light calibration system

To obtain the gain of SiPM, light calibration system was designed. Extremely short light generated by LED could stimulate SiPM to generate electrical signals, fig.7 shows the single photoelectron spectrum observed with this system.

## Prototype test

The performance of the readout electronics system is good enough to meet the demands of prototype. After long-term test the readout system maintains a good state. Fig. 8 and Fig. 9 show the track result of the cosmic-ray test and the beam test.

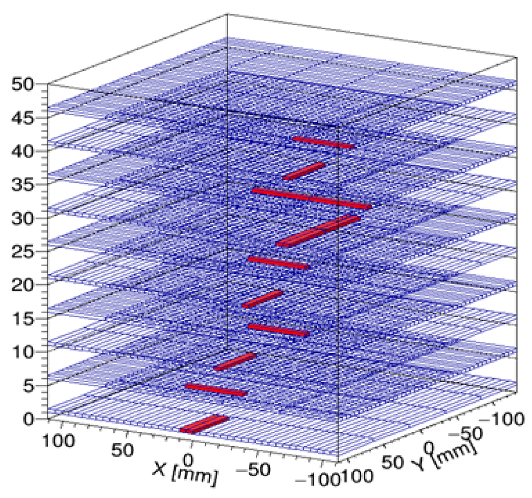


*Fig. 8 Result of long-term cosmic ray test*

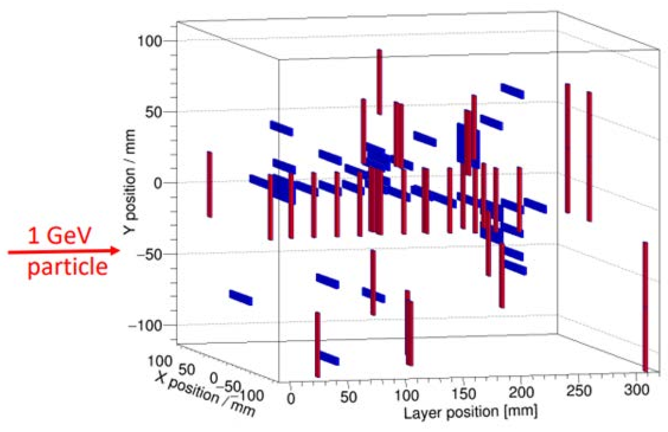



*Fig. 9 Result of beam test*

## Contact

EMAIL: henzt@ustc.edu.cn

Address: Department of modern physics, China University of science and technology, Hefei, Anhui, China

## Thanks

Study was supported by the National Natural Science Foundation of China (11635007) and the National Key Program for S&T Research and Development (Grant No.:2016YFA0400400).